

Article

Application of Lean Ergonomics to Reduce Motion Waste, Musculoskeletal Complaints, and Work Fatigue in Tempeh MSMEs

Endang Widuri Asih^{1*}, I G. Adiatmika², I M. Muliarta², I.B. Alit Swamardika³

¹Industrial Engineering, Universitas AKPRIND Indonesia

²Ergonomics Physiology, Faculty of Medicine, Udayana University, Indonesia

³Electrical Engineering, Udayana University

Correspondence: endang@akprind.ac.id

ABSTRACT

Background: Tempeh Micro, Small, and Medium Enterprises (MSMEs) are largely home-based industries that rely on manual production processes. These manual tasks often involve inefficient movements, leading to musculoskeletal disorders and significant work fatigue.

Objectives: This study aims to implement a Lean Ergonomics approach to reduce motion waste, musculoskeletal complaints, and work fatigue among workers in the tempeh industry. **Method:** This experimental study used a within-subject design (treatment-by-subject). The research was conducted in two phases: before improvement (P1) and after improvement (P2). Data collection involved identifying waste, analyzing work posture using the Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA), measuring musculoskeletal complaints via the Nordic Body Map (NBM), and assessing fatigue levels using the Industrial Fatigue Rating Committee (IFRC) questionnaire.

Results: Interventions included redesigning worktables to improve posture, implementing the 5S methodology to refine work methods, and optimizing the facility layout. The results demonstrated a significant reduction in unnecessary movements, decreasing from 15 in P1 to 7 in P2. Work posture scores improved, with RULA and REBA scores decreasing by 1.81 and 2.87, respectively. Furthermore, musculoskeletal complaints decreased by 22.4% (9.31 points), and work fatigue levels were reduced by 22.14%.

Conclusion: The application of Lean Ergonomics effectively reduces motion waste, improves work posture, and lowers levels of musculoskeletal pain and fatigue. These improvements enhance overall work comfort and performance within tempeh MSMEs.

Keywords: Lean Ergonomics, Motion Waste, Musculoskeletal Complaints, Work Fatigue

INTRODUCTION

The tempeh industry is a small-scale industry capable of absorbing a large number of workers, both those directly involved in the production process and those engaged in the trade of raw materials and processed products. The prospects of the tempeh industry are very promising, as indicated by data from the Central Bureau of Statistics (BPS) in 2021, which shows that the average per capita consumption of tofu and tempeh in Indonesia reached 0.304 kilograms (kg) per week. This figure increased by 3.75% compared to the previous year, which was 0.293 kg per week (Karnadi; & Pramesthi, 2022). This indicates that tempeh plays a significant role in improving community nutrition, especially among lower- and middle-income groups. However, most tempeh industries still operate in the form of Micro, Small, and Medium Enterprises (MSMEs) and are largely managed using traditional methods.

Citation: Asih, E. W., Adiatmika, I. G., Swamardika, I. B. A. (2026). Application of Lean Ergonomics to Reduce Motion Waste, Musculoskeletal Complaints, and Work Fatigue in Tempeh MSMEs. Bali Medical and Wellness Journal, 3(1), 44-54. DOI:

<https://doi.org/10.7134/1/bmwj.v3i1.55>

Submitted: March, 03 2026

Revised: April, 11 2026

Accepted: April, 21 2026

Published: April, 30 2026



This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Tempeh MSMEs face various problems in the production process, including traditional production methods, non-ergonomic working conditions, inefficiency, and improper waste disposal (Asih et al., 2020). The production process, including yeast mixing and packaging, is carried out manually using simple work facilities. These conditions often lead to inefficient work activities and pose risks to occupational health. Workers frequently perform tasks involving unnecessary movements and non-ergonomic postures such as bending, squatting, over reaching, repetitive, and static movements. These conditions may result in musculoskeletal complaints and work fatigue.

Occupational fatigue and the prevalence of Musculoskeletal Disorders (MSDs) indicate that fatigue can exacerbate pain symptoms and MSDs among workers (Sharif et al., 2024). In addition, Work-Related Musculoskeletal Disorders (WRMSDs) and fatigue are often interrelated and serve as significant predictors of musculoskeletal disorders in specific work environments (Fan et al., 2024). The musculoskeletal complaints experienced by tempeh workers commonly include pain in the lower back, legs, back, and both shoulders. Fatigue assessments show that workers often experience fatigue in the legs, whole body, instability while standing, stiffness in the shoulders, and lower back pain. If these conditions persist over time, they may increase the risk of musculoskeletal and spinal disorders, such as low back pain. These physiological disturbances include musculoskeletal disorders and general complaints. Additionally, workers often experience tingling in their legs due to impaired blood circulation caused by static muscle activity (Kroemer, 2017).

Motion waste increases physical workload without adding value to the product. This condition accelerates the musculoskeletal complaints and work fatigue, which ultimately reduces workers' speed, accuracy, and work capacity, thereby decreasing productivity (Daneshmandi et al., 2017). The waste problems in the tempeh production process have the potential to increase musculoskeletal complaints and fatigue, and reduce productivity. Therefore, they must be reduced or eliminated. One method that can be used to eliminate the wastes is the Lean Ergonomics approach. Lean Ergonomics is an integrative approach that combines lean manufacturing principles with ergonomics to simultaneously eliminate waste and reduce workers' physical and mental workload, thereby improving performance, productivity, and system sustainability (Brunner et al., 2024).

This study aims to reduce motion waste, musculoskeletal complaints, and work fatigue through the implementation of Lean Ergonomics in tempeh MSMEs. Several studies have integrated lean and ergonomics concepts, including research in hybrid assembly environments, digital fields, operational management, and setup reduction management in metallurgical factories (Botti et al., 2017); (B. C. Brito et al., 2017); (Brunner et al., 2024); (Brunner et al., 2022). According to (Aripin et al., 2024) and (Hizam et al., 2024) in their systematic literature review, Lean Ergonomics is important to be applied in research on Small and Medium Enterprises (SMEs).

Several studies related to tempeh products, environment, and production processes have also been conducted. (Novari & Ma'ruf, 2025) discussed quality control, (Kadar et al., 2020) examined metabolic changes during fermentation, and (Abdulahkim et al., 2020) focused on redesigning soybean skin separator tools based on user needs. However, these studies primarily focus on production

processes and environmental aspects, while research related to human resources, particularly workers and occupational health, remains limited.

Therefore, this study focuses on the implementation of Lean Ergonomics among workers in the tempeh packaging process to reduce motion waste, musculoskeletal complaints, and work fatigue. The improvements implemented in this study include enhancing work posture and movements through redesigning work tables and improving work methods in the tempeh packaging process using the 5S approach. The research method involves identifying work waste and analysing work posture measurements. This demonstrates that Lean Ergonomics can improve the overall work system.

METHODS

Study Design

This study employed an experimental within-subject design, also referred to as a treatment-by-subject design. Measurements were conducted in two phases: before improvement (Period 1/P1) and after improvement (Period 2/P2). The pre-improvement phase represented conventional working conditions without ergonomic modifications, while the post-improvement phase was conducted following the implementation of ergonomic improvements.

Setting and Participants

The research was carried out among workers in tempeh micro, small, and medium enterprises (MSMEs) who were directly involved in the production process. Participants were selected according to specific inclusion and exclusion criteria. Eligible workers were aged between 18 and 50 years, had a body mass index (BMI) within the normal range of 19–25, were physically healthy as confirmed by medical examination, had completed at least junior high school education, possessed a minimum of six months of work experience, and expressed willingness to participate until the completion of the study. Workers with severe health conditions or cognitive limitations were excluded.

Materials and Instruments

Several standardized instruments were used to evaluate outcomes. Musculoskeletal complaints were measured using the Nordic Body Map (NBM) questionnaire, while work fatigue levels were assessed using the Industrial Fatigue Rating Committee (IFRC) questionnaire. Work posture was evaluated using the Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA). In addition, Ergonomics Lean Approach (ELA) mapping and Ergo Value Stream Mapping (Ergo-VSM) were employed to identify waste and ergonomic risks in the production process. Ergo-VSM, an extension of conventional value stream mapping, integrates ergonomic indicators such as posture, repetitive movements, workload, and musculoskeletal complaints.

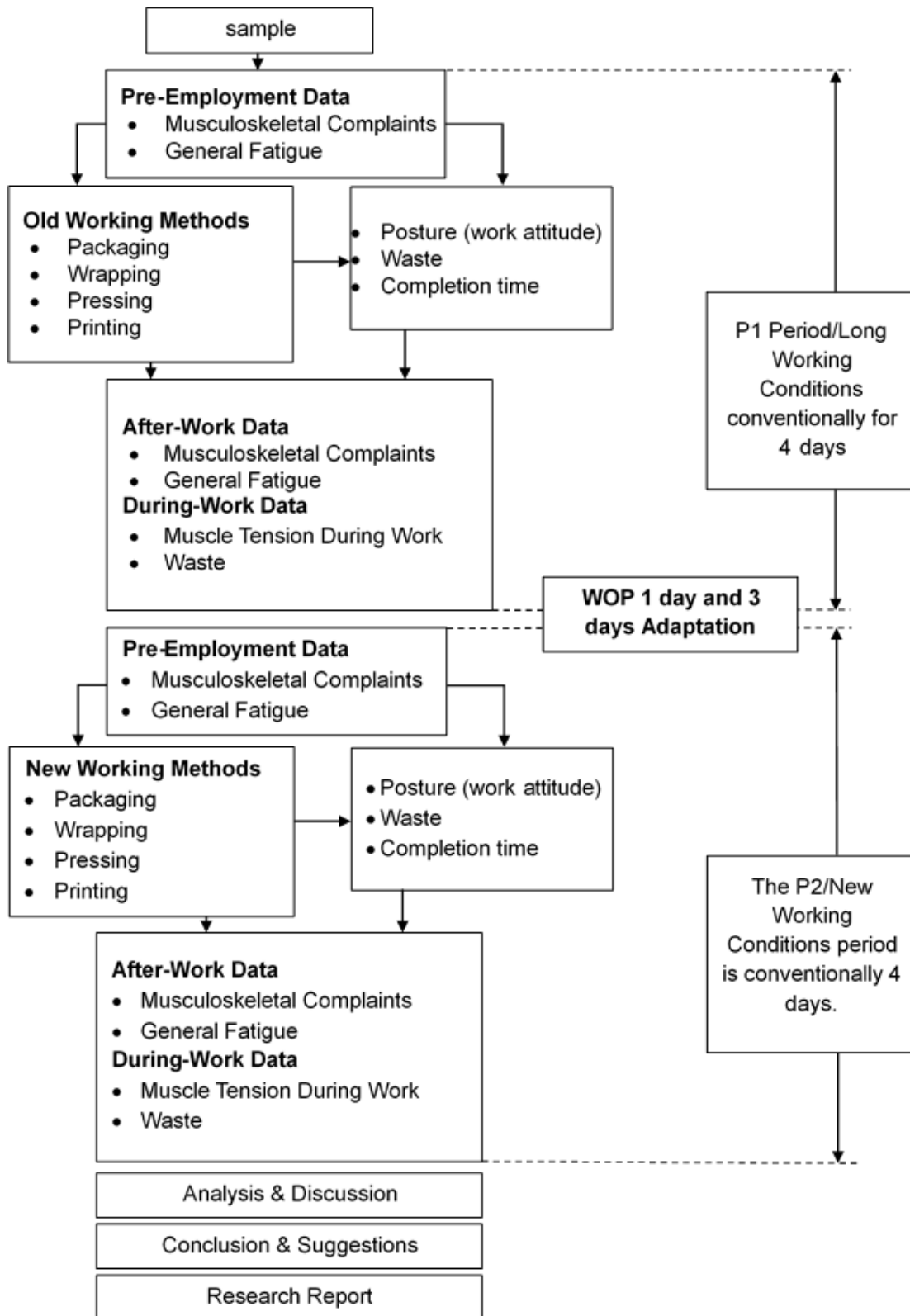


Figure 1. Research Flow

Data Collection Procedures

During Period 1 (P1), data were collected over seven consecutive days under conventional working conditions. Subjective data on musculoskeletal complaints and fatigue were obtained through questionnaires administered before and after work. Work activities were recorded to distinguish productive and non-productive movements, and interviews with workers, owners, and supervisors were conducted to classify value-added (VA), non-value-added (NVA), and necessary non-value-added (NNVA) activities. Motion waste was identified using the zero-one method, in which a score of 1 indicated the presence of waste and 0 indicated its absence. The findings were mapped using ELA to illustrate workflow, operations, inspections, transportation, storage, waiting, distance, time, and ergonomic risk factors. These results were then integrated into Ergo-VSM to provide a comprehensive overview of waste and ergonomic risks.

Following P1, a washing out and adaptation period was conducted over four days. One day was designated as “without production/work” (WOP), during which workers refrained from heavy tasks but continued to receive wages. This was followed by three days of adaptation, during which workers trialed the redesigned facilities and layouts. Socialization and orientation sessions introduced the principles of Lean Ergonomics and familiarized workers with the improved working conditions.

Period 2 (P2) was conducted over seven consecutive days after the ergonomic improvements were implemented. The same procedures as in P1 were repeated, but all activities were carried out under improved working conditions. The ergonomic interventions included redesigning work tables and chairs to replace floor-level working postures, and reorganizing facility layouts to minimize unnecessary movements. These improvements were based on workers’ anthropometric data and Lean Ergonomics principles, with the aim of reducing musculoskeletal complaints, fatigue, and motion waste.

Data Analysis

Data were processed and analyzed using SPSS version 20.0 for Windows. Descriptive statistics were used to summarize participant characteristics and baseline findings. The Shapiro–Wilk test was applied to assess data normality. For normally distributed data, paired t-tests were used to compare pre- and post-intervention results, while the Wilcoxon Signed Rank Test was applied to non-normally distributed data. Statistical analyses were conducted on musculoskeletal complaint scores, general fatigue scores, and work posture scores, with a significance level set at $\alpha = 0.05$.

RESULTS

Subject Characteristics

The study subjects consisted of 16 workers, all of whom participated from the beginning to the end of the study. The majority of subjects were male (87.5%), while 12.5% were female. In terms of education level, 69% had completed senior high school/vocational school, and 31% had completed junior high school. The average work experience was 7.3 years. The measurement results showed that the average

Body Mass Index (BMI) was 20.8. The mean systolic blood pressure was 125.25 mmHg, and the diastolic pressure was 78.62 mmHg. The average resting heart rate was 81.38 beats per minute in Period 1 and 78 beats per minute in Period 2. These results indicate that the subjects were experienced and productive in their work. Higher work experience is associated with increased productivity (Santoso, 2023). All subjects were in good health based on physical examinations, blood pressure, and resting heart rate measurements. Therefore, they were considered suitable as research samples.

Waste Identification

Waste identification and measurement were conducted during the tempeh packaging process, including wrapping, sealing, pressing, printing, and storing. The identification was based on the seven types of waste (Mulyana et al., 2023). The results were evaluated using the zero-one method by workers and business owners. Four types of waste were identified in the tempeh production process, namely: Unnecessary motion 40%, Inefficient transportation 20%, Overproduction 18% and Defects: 12% After the zero-one assessment and improvements, the processes in Period 1 (P1) and Period 2 (P2) were mapped using the Ergonomic Lean Approach (ELA) and further illustrated using Ergo Value Stream Mapping (Ergo-VSM).

Table 1. Recapitulation of Ergo-VSM Measurement Results (P1 & P2)

Condition	P1	P2
Activity (minutes)		
VA (Value Added)	3.4	6.5
NVA (Non Value Added)	1.7	0
NNVA (Necessary Non Value Added)	2.0	0.7
WS (Workstation time)	31.6	23.4
Information (minutes)		
Operation	21	14
Transportation	3.5	2.2
Ergonomic Risk (count)		
Posture	7	3
Motion	15	7
Contact stress	–	–

The results of waste identification indicated the presence of motion waste, which consequently led to work posture waste. Therefore, this study assessed work posture waste using the Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) methods. The measurement of posture-related waste in small industries and MSMEs using RULA and REBA has been supported by previous studies (Aripin, et al., 2024). These measurements were conducted on the work posture during the tempeh packaging process in Period 1 (P1) and Period 2 (P2). Based on the RULA and REBA assessments, the normality test results showed that the data for P1 and P2 were not normally distributed ($p < 0.05$). Therefore, the

difference test was conducted using the Wilcoxon Signed Rank Test. The results of the difference test are presented in Table 2.

Table 2. Work Posture Measurement Results (RULA & REBA)

Variable Comparison	Mean P1	Mean P2	Test	Z / t	p-value	Decision
P2_RULA – P1_RULA	6.75	3.94	Wilcoxon	-3.134	0.002	Significant difference
P2_REBA – P1_REBA	7.62	4.75	Wilcoxon	-2.739	0.006	Significant difference

Musculoskeletal Complaints

Musculoskeletal complaints were measured subjectively using the Nordic Body Map (NBM) questionnaire during the tempoh packaging process, both before and after work in Periods P1 and P2. Scores were calculated and averaged. Normality testing using the Shapiro-Wilk test showed that:

Pre-work scores in P1 and P2 were not normally distributed ($p < 0.05$)

Post-work scores in P1 and P2 were normally distributed ($p > 0.05$)

Therefore, the Wilcoxon Signed Rank Test was used. The results of the difference test can be seen in Table 3.

Table 3. Differences in Musculoskeletal Complaints (P1 & P2)

Variable Comparison	Mean P1	Mean P2	Z / t	p-value	Decision
P1 Before – P1 After	32.44	41.56	-3.469	0.001	Significant difference
P2 Before – P2 After	31.94	32.25	-0.678	0.498	No significant difference
P1 Before – P2 Before	32.44	31.94	-1.293	0.196	No significant difference
P1 After – P2 After	41.56	32.25	9.093	0.000	Significant difference

General Fatigue

General fatigue was assessed using a 30-item questionnaire (rating scale) developed by the Japan Association of Industrial Health, with a 4-point Likert scale administered to 16 workers. Measurements were conducted before and after work in both P1 (pre-intervention) and P2 (post-intervention). Normality test results showed:

Non-normal distribution: P1 after work, P2 before work ($p < 0.05$)

Normal distribution: P1 before work, P2 after work ($p > 0.05$)

Therefore, the Wilcoxon Signed Rank Test was used. The results of the difference test can be seen in Table 4.

Table 4. Differences in General Fatigue

Variable Comparison	Mean P1	Mean P2	Z	p-value
P1 Before – P1 After	35.81	42.31	-3.417	0.001
P2 Before – P2 After	32.28	33.94	-0.748	0.454
P1 Before – P2 Before	35.81	32.28	-2.854	0.064
P1 After – P2 After	42.31	33.94	-3.519	0.000

DISCUSSION

. The findings of this study highlight that workers in tempeh MSMEs, despite being physically fit and experienced, were exposed to significant ergonomic risks due to inefficient work methods and layouts. Waste identification revealed that unnecessary motion was the most prevalent problem, followed by transportation waste. These inefficiencies were linked to repetitive movements, awkward postures, and disorganized tool placement, all of which contributed to musculoskeletal complaints and fatigue. Such risks are consistent with previous studies showing that repetitive and awkward movements increase cumulative strain on muscles and nerves, thereby elevating the likelihood of musculoskeletal disorders (Winiarski et al., 2025).

The ergonomic redesign of workstations, based on anthropometric data, successfully improved working posture. By adjusting table height, width, and length to match workers' physical dimensions, the intervention reduced excessive bending, squatting, and reaching. The foldable design optimized limited workspace, while drawers facilitated waste flow. Post-intervention assessments using RULA and REBA demonstrated significant reductions in risk scores, shifting from high-risk to moderate-risk categories. Although further improvements are needed to achieve low-risk levels, these results confirm that workstation redesign is an effective strategy for reducing musculoskeletal strain and enhancing worker safety.

The implementation of the 5S method (Sort, Set in order, Shine, Standardize, Sustain) and facility layout improvements further reduced motion and transportation waste. Organizing tools and materials within easy reach minimized unnecessary searching and movement, while cleaning and standardization reinforced discipline and efficiency. Facility layout adjustments, such as repositioning storage racks and weighing scales closer to workstations, shortened transportation time and improved workflow. These changes reduced motion waste from 15 to 7 movements and transportation time from 3.5 to 2.2 minutes, demonstrating measurable gains in efficiency and ergonomic safety.

Musculoskeletal complaints were concentrated in the neck, shoulders, back, and lower back, reflecting the physical demands of repetitive and static postures. While baseline complaints before work were similar across both periods, post-work complaints decreased significantly after ergonomic improvements. The mean score reduction of 9.31 points (22.40%) indicates that interventions provided opportunities for muscle relaxation and recovery. This outcome underscores the importance of ergonomic restructuring in mitigating strain from monotonous and repetitive tasks.

Fatigue levels also improved markedly following ergonomic interventions. In Period 1, fatigue scores increased significantly after work, reflecting the cumulative impact of poor posture and inefficient workflows. In contrast, in Period 2, fatigue scores remained stable before and after work, with a significant reduction of 9.37 points (22.14%) compared to the pre-improvement phase. These findings suggest that ergonomic improvements not only reduced physical workload but also enhanced physiological adaptation, thereby preventing fatigue accumulation. Similar results have been reported in other industries, where ergonomic redesigns

reduced fatigue by 25–33% (Suarbawa et al., 2016; Ruliati et al., 2017; Suarjana et al., 2018).

The integration of Lean Ergonomics principles—combining workstation redesign, 5S implementation, and facility layout optimization—proved effective in reducing waste, musculoskeletal complaints, and fatigue. These interventions require minimal investment yet yield substantial improvements in worker health, safety, and productivity. For SMEs, where resources are often limited, such approaches offer practical and sustainable solutions to enhance efficiency and reduce occupational risks.

Limitations and Future Directions

This study was limited by its small sample size and single-site design, which restrict generalizability. The absence of a control group also limits causal attribution. Furthermore, while ergonomic risks were reduced to moderate levels, further refinements are needed to achieve low-risk categories. Future research should involve larger samples, multiple sites, and longer follow-up periods to assess the durability of improvements. Incorporating validated instruments for fatigue and musculoskeletal assessment, alongside objective productivity measures, would strengthen evidence for broader application.

CONCLUSION

The study demonstrates that ergonomic interventions grounded in Lean Ergonomics principles can significantly reduce motion and transportation waste, musculoskeletal complaints, and fatigue among tempeh MSME workers. By aligning workstation design with anthropometric data, implementing 5S practices, and optimizing facility layouts, working conditions improved from high-risk to moderate-risk categories. These findings highlight the potential of simple, cost-effective ergonomic strategies to enhance occupational health and productivity in small-scale industries. Continued refinement and broader application of these interventions are essential to achieve long-term worker safety and efficiency.

CONFLICT OF INTEREST

No benefits in any form have been or will be received from any party related directly or indirectly to the subject of this paper. No conflict of interest.

FUNDING

No funds were received in support of this work.

REFERENCES

- Abdulhakim, F., Kusnayat, A., & Martini, S. (2020). an Improved Design of a Soybean Peel Separator for Tempe Production. *Knowex Food and Agriculture*, 1(1), 2–12. <https://doi.org/10.17501/2682728x.2020.1102>
- Aripin, Norhana Mohd.; Mahmud, F. et al. (2024). Systematic literature review : lean ergonomics analysis in small & medium enterprises (smes) manufacturing sector Norhana Mohd Aripin , Fatimah Mahmud , Lee Khai Loon and Suhaidah Hussain Faculty of Industrial Management , Universiti Malaysia Pahang Al-. 19(1), 89–108.



- Aripin, N., Mahmud, F., Lee, K. L., & Hussain, S. (2024). Systematic Literature Review: Lean Ergonomics Analysis In Small & Medium Enterprises (Smes) Manufacturing Sector. *Journal of Technology and Operations Management*, 19, 89–108. <https://doi.org/10.32890/jtom2024.19.1.7>
- Asih, E. W., Mawadati, A., & Lestari, N. (2020). Ergonomic Design for Tempe Production Tool Based on User Voice. *IOP Conference Series: Materials Science and Engineering*, 807(1). <https://doi.org/10.1088/1757-899X/807/1/012037>
- Botti, L., Mora, C., & Regattieri, A. (2017). Integrating ergonomics and lean manufacturing principles in a hybrid assembly line. *Computers & Industrial Engineering*, 111. <https://doi.org/10.1016/j.cie.2017.05.011>
- Bridger, R. (2018). *Introduction to Human Factors and Ergonomics 4th Edition*.
- Brito, B. C., Forsberg, B. R., Kasper, D., Amaral, J. H. F., de Vasconcelos, M. R. R., de Sousa, O. P., Cunha, F. A. G., & Bastos, W. R. (2017). The influence of inundation and lake morphometry on the dynamics of mercury in the water and plankton in an Amazon floodplain lake. *Hydrobiologia*, 790(1), 35–48. <https://doi.org/10.1007/s10750-016-3017-y>
- Brito, M., & Gonçalves, M. A. (2020). ErgoSMED: A Methodology to Reduce Setup Times and Improve Ergonomic Conditions. *Advances in Intelligent Systems and Computing*, 1026, 549–554. https://doi.org/10.1007/978-3-030-27928-8_83
- Brito, M., Ramos, A. L., Carneiro, P., & Gonçalves, M. A. (2018). Lean M. *International Journal of Occupational and Environmental Safety*, 2(2), 21–31. <https://doi.org/10.24840/2184-0954>
- Brunner, S., Knott, V., & Bengler, K. (2022). Lean Ergonomics—Are relevant synergies of digital human models and digital twins defining a new emerging subdiscipline? *Zeitschrift Für Arbeitswissenschaft*, 76(4), 401–415. <https://doi.org/10.1007/s41449-022-00344-4>
- Brunner, S., Siebenbürger, M., Kühnel, K., & Bengler, K. (2024). Promoting human-centered manufacturing through Lean Ergonomics—a structural equation model for ergonomics and management data. *Production and Manufacturing Research*, 12(1). <https://doi.org/10.1080/21693277.2024.2398086>
- Daneshmandi, H., Choobineh, A., Ghaem, H., & Karimi, M. (2017). Adverse Effects of Prolonged Sitting Behavior on the General Health of Office Workers. *Journal of Lifestyle Medicine*, 7(2), 69–75. <https://doi.org/10.15280/jlm.2017.7.2.69>
- Fan, J., Tan, X., Smith, A. P., & Wang, J. (2024). Work-related musculoskeletal disorders, fatigue and stress among gas station workers in China: A cross-sectional study. *BMJ Open*, 14(7), 1–8. <https://doi.org/10.1136/bmjopen-2023-081853>
- Gapp, R., Fisher, R., & Kobayashi, K. (2017). Implementing 5S within a Japanese context: An integrated management system. *Management Decision*, 46(4), 565–579. <https://doi.org/10.1108/00251740810865067>
- Gusti Naufal Paleva, F., Bambang Gusminto, E., & Budi Susanto, A. (2024). Volume 12 Nomor 3 Halaman 689-706 *Jurnal Ilmu Manajemen Pengaruh transformational leadership dan self-efficacy terhadap job performance melalui employee engagement (studi kasus sektor publik di pemerintahan Kabupaten Jember)*. 12, 689–706.
- Hidayatullah, S. R. (2022). *Jurnal Ilmu Kesehatan Masyarakat JURNAL ILMU KESEHATAN MASYARAKAT*. *Jurnal Ilmu Kesehatan*, 14(01), 93–112. <https://journal.umg.ac.id/index.php/manajerial/article/view/10630>
- Hizam, A. S., Mohamed, N., & Nelfiyanti. (2024). Study of SME employees' awareness level on lean manufacturing and ergonomics implementation in Malaysian and Indonesian production environments. *Heliyon*, 10(18), e38216. <https://doi.org/10.1016/j.heliyon.2024.e38216>
- Kadar, A. D., Astawan, M., Putri, S. P., & Fukusaki, E. (2020). Metabolomics based study of the effect of raw materials to the end product of tempe—an Indonesian fermented soybean. *Metabolites*, 10(9), 1–11. <https://doi.org/10.3390/metabo10090367>
- Karnadi, & Pramesthi, R. A. (2022). *Universitas Abdurachman Saleh Situbondo Riska Ayu Pramesthi*. 19(1), 80–97.
- Kroemer, K. (2017). *Fitting the Human: Introduction to Ergonomics / Human Factors Engineering*. <https://doi.org/10.1201/9781315398389>

- Mulyana, I. J., Singgih, M. L., Partiw, S. G., & Hermanto, Y. B. (2023). Identification and Prioritization of Lean Waste in Higher Education Institutions (HEI): A Proposed Framework. *Education Sciences*, 13(2). <https://doi.org/10.3390/educsci13020137>
- Novari, I., & Ma'ruf, A. (2025). Implementasi Pengawasan Mutu dalam Proses Produksi Tempe Segar di Rumah Tempe Indonesia (RTI) Bogor. *Karimah Tauhid*, 4(9), 7286–7292. <https://doi.org/10.30997/karimahtauhid.v4i9.21168>
- Rezki, A. S., Maksum, A. H., Herwanto, D., & Rahmat, M. T. (2023). Analisis Risiko Postur Kerja dengan Metode Nordic Body Map, RULA dan REBA pada Proses Manual Material Handling Pabrik Kecap. *Jurnal Media Teknik Dan Sistem Industri*, 7(2), 86. <https://doi.org/10.35194/jmtsi.v7i2.2677>
- Ruliati, L., Adiputra, N., Sutjana, I., & Sutajaya, I. (2017). Modification of working conditions based on ergo THK reducing workload, muscle tension, and fatigue of rice milling workers in J village. In *AIP Conference Proceedings (Vol. 1902)*. <https://doi.org/10.1063/1.5010659>
- Santoso, M. H. B. (2023). Peran Mediasi Produktivitas Kerja Pada Hubungan Kompensasi, Lingkungan Kerja, Motivasi dan Disiplin Kerja Terhadap Kinerja Karyawan (Study Pada Lupi Bakery). 6(0), 167–186.
- Sharif, S., Ahmad, N., Pow Yean, C., Shaharuddin, G. S., & Tung Er, C. (2024). Exploring Listening Strategies in Language Learning. *International Journal of Academic Research in Business and Social Sciences*, 14(7), 65–81. <https://doi.org/10.6007/ijarbss/v14-i7/21707>
- Strain, T., Flaxman, S., Guthold, R., Semenova, E., Cowan, M., Riley, L. M., Bull, F. C., Stevens, G. A., Abdul Raheem, R., Agoudavi, K., Alfred Anderssen, S., Alkhatib, W., Aly, E. A. H., Anjana, R. M., Bauman, A., Bovet, P., Brito Moniz, T., Bulotaitė, G., Caixeta, R., ... Zoma, L. R. (2024). National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: a pooled analysis of 507 population-based surveys with 7 million participants. *The Lancet Global Health*, 12(8), e1232–e1243. [https://doi.org/10.1016/S2214-109X\(24\)00150-5](https://doi.org/10.1016/S2214-109X(24)00150-5)
- Suarbawa, J., Adiputra, N., Pangkahila, J., & Sutjana, I. (2016). Work Posture Improvement Using Ergonomic Approach Decreases Subjective Disorders of Perapen Workers on the Process of Nguwad Gamelan in Bali. *International Research Journal of Engineering, IT & Scientific Research*, 2, 7. <https://doi.org/10.21744/irjeis.v2i9.164>
- Suarjana, I. W. G., Adiatmika, I. P., & Adnyana, I. (2018). Redesain alat pamarut kelapa mengurangi beban fisiologis dan meningkatkan produktivitas kerja pada pekerja industri adonan (luluh) sate di desa kaba-kaba kediri tabanan. *Jurnal Ergonomi Indonesia (The Indonesian Journal of Ergonomic)*, 4, 39. <https://doi.org/10.24843/JEI.2018.v04.i02.p05>
- Suhardi, B., Juwita, E., & Astuti, R. D. (2019). Facility layout improvement in sewing department with Systematic Layout planning and ergonomics approach. *Cogent Engineering*, 6(1). <https://doi.org/10.1080/23311916.2019.1597412>
- Sumasto, F., Saputri, S. H., Awani, R. S., Maulana, A., Simanjuntak, K., Ismono, A., & Supardi, S. (2023). Penerapan Prinsip 5S untuk Mengurangi Waste Motion dalam Proses Layanan Galon R-Water. *Jurnal Serambi Engineering*, 9(1), 7788–7794. <https://doi.org/10.32672/jse.v9i1.742>
- Susihono, W., & Adiatmika, I. P. G. (2021). The effects of ergonomic intervention on the musculoskeletal complaints and fatigue experienced by workers in the traditional metal casting industry. *Heliyon*, 7(2), e06171. <https://doi.org/10.1016/j.heliyon.2021.e06171>
- Winiarski, S., Molek-Winiarska, D., & Chomątowska, B. (2025). From Motion to Prevention: Evaluating Ergonomic Risks of Asymmetrical Movements and Worker Well-Being in an Assembly Line Work. *Applied Sciences (Switzerland)*, 15(2), 1–19. <https://doi.org/10.3390/app15020560>